Making Light Work Lighter

General Photonics Corporation

WSL-1000

Polarization Stabilized Wavelength Swept Laser

Operation Manual

Version 1.1

Oct 13, 2009

General Photonics Corp.
5228 Edison Ave.
Chino, CA 91710 USA

Ph: (909) 590-5473
Fax: (909) 902-5536
www.generalphotonics.com

Table of Contents

WARRANTY 3
SAFETY CONSIDERATIONS 4
ATTENTION 4
Section 1 Overview 5
Section 2 Specifications 6
Section 3 Feature Description 7
3.1 Basic Operation Scheme 7
3.2 Frequency Clock 7
3.3 Instantaneous Power Monitor 9
3.4 Interface Descriptions 10
3.4.1 Front panel 10
3.4.1 Rear panel 10
Section 4 Programming and Control 11
4.1 Programming 11
4.1.1 RS-232 connection 11
4.1.2 Programming Commands 11
4.2 Remote Control Toolkit 14
4.2.1 Introduction 14
4.2.2 Basic Information 15
4.2.3 Configuration 16
4.2.4 Status Report 17
Section 5 Operation Instructions 19
Section 6 Technical Support 23

WARRANTY

All of General Photonics' products have been inspected and found to comply with our stringent quality assurance standards before shipping. If any damage occurs during shipment, please contact the carrier and inform us or our distributors as soon as possible. Please do not, under any circumstances, attempt user repair of any General Photonics product. To avoid further damage, any repair of defective products must be performed by well-trained engineers.

General Photonics warrants that this product will be free from defects in materials or workmanship for a period of one year from the date of original shipment (listed on the certificate of quality or packing list enclosed with the original shipment). A product found to be defective during the warranty period will be repaired or replaced, at no charge, at General Photonics' option.

If a problem is found, please contact General Photonics for assistance. If necessary, return the defective product, freight prepaid, clearly labeled with the RMA number, with as complete a description of the problem as possible. The repaired or replacement product will be returned, freight prepaid, as soon as possible.

The above warranty specifically excludes products that have been repaired or modified by non-manufacturer-authorized personnel, as well as damage caused by misuse, abuse, improper storage or handling, or acts of nature.

This warranty is in lieu of all other warranties, expressed or implied. General Photonics will not be liable for any indirect or consequential damages or losses resulting from the use of its products.

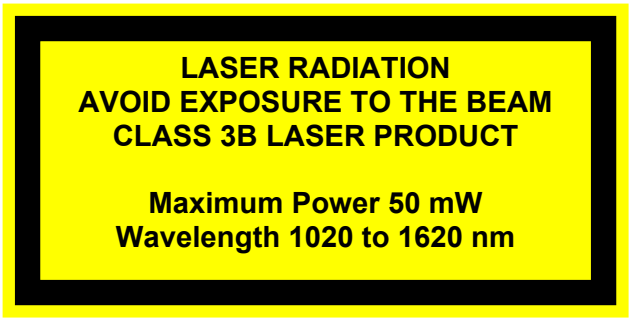
SAFETY CONSIDERATIONS

The following safety precautions must be observed during operation, service and repair of this instrument. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended use of the instrument. General Photonics Corp. assumes no liability for customers' failure to comply with these requirements.

• Before operation, the user should inspect the instrument and review the manual carefully.

• Make sure that the instrument is in a secured work environment (in terms of temperature, humidity, electrical power, hazard due to fire or shock, etc.) for proper operation.

• WSL-1000 belongs to Class 3B laser. The laser radiation is invisible to human eye, but it is hazardous if the eye is exposed directly. Do not look into the optical output when this unit is operating.



ATTENTION

- Since WSL-1000 is delicate precision instrument with optical alignment, it must be placed on a stable platform to avoid the vibration.

Section 1 Overview

The WSL-1000 is a high-speed tunable laser for fiber sensor and OCT applications. The laser's wavelength can be swept at a frequency of up to 16 kHz across a spectral range of up to 150 nm, with an output optical power of up to 20 mW. The device outputs two λ-trigger (TTL) signals to indicate the exact starting and ending wavelengths of each wavelength sweep. It also outputs an optical frequency clock (TTL) with a spacing down to 20 GHz as the laser is swept to give users instantaneous relative optical frequency marks. In combination with the λ-trigger, this allows the absolute frequency or wavelength of the laser to be known at each instant during each wavelength sweep. In addition, a power monitoring output is included to indicate the instantaneous laser output power at each wavelength. The WSL-1000 is also equipped with a built-in variable optical attenuator (VOA). Other laser health parameters, such as laser average power, driving current, and chip temperature, are also provided via digital interfaces. Finally, the laser incorporates automatic polarization optimization to guarantee long term stability. The WSL-1000 is available with either a linearly polarized output (aligned to the slow axis of a PM fiber) or a depolarized output. This combination of features makes it a flexible tool for research in fiber sensing, optical coherence tomography (OCT), or similar applications.

Fig. 1 WSL-1000

Section 2 Specifications

General:

Operating temperature	0 ~ 50 °C
Storage temperature	−20 ~ 70 °C
Humidity	Relative humidity 85% without condensation
Power supply	100-240 V universal power supply
Control Interface	RS-232, Ethernet, USB, GPIB
Power on Indicator	LED[1]

Physical Features:

Dimensions	2U, ¾ of 19" rack width, 3.5"(H) × 14" (W) × 14" (L)
Display	2-line by 20 character LCD display
Output Fiber Type	PM or SM (Specify when ordering)
Fiber Output Connector	FC/APC

Optical Characteristics:

Operating center wavelength	1060, 1310, 1550 nm +/- 20 nm
Spectral range (-10dB cutoff)[2]	1310 / 1550 nm: 120 ~ 150 nm; 1060 nm: ~ 60 nm (Specify when ordering)
Repetition rate	up to 16 KHz (Specify when ordering)
Sweep average power[2]	10-20 mW (Specify when ordering)
Static peak output power[2]	> 20 mW but <50mW
Coherence length	>7 mm
Variable Optical Attenuation	20 dB
Polarization Extinction ratio	> 20 dB (For linearly polarized option)
Degree of polarization	< 5% (For depolarized output option)
Reference wavelength triggers	λ_{min} and $\lambda_{max,}$ user selectable
Optical frequency clock spacing	20, 25, 30, 35, 40, 45, 50 GHz, user selectable

Electrical Characteristics:

Reference wavelength triggers	TTL pulse at start (λ_{min}) and end (λ_{max}) of each sweep
Sweep sync pulse	TTL
Optical frequency clock	TTL
Instantaneous power monitor	Analog, 0-5V

[1] LED only indicates internal 5V power supply which is laser power supply.
[2] This is the typical value for 10KHz@1310 nm module. Value may be different at higher sweep rate and other wavelength

Section 3 Feature Description

3.1 Basic Operation Scheme

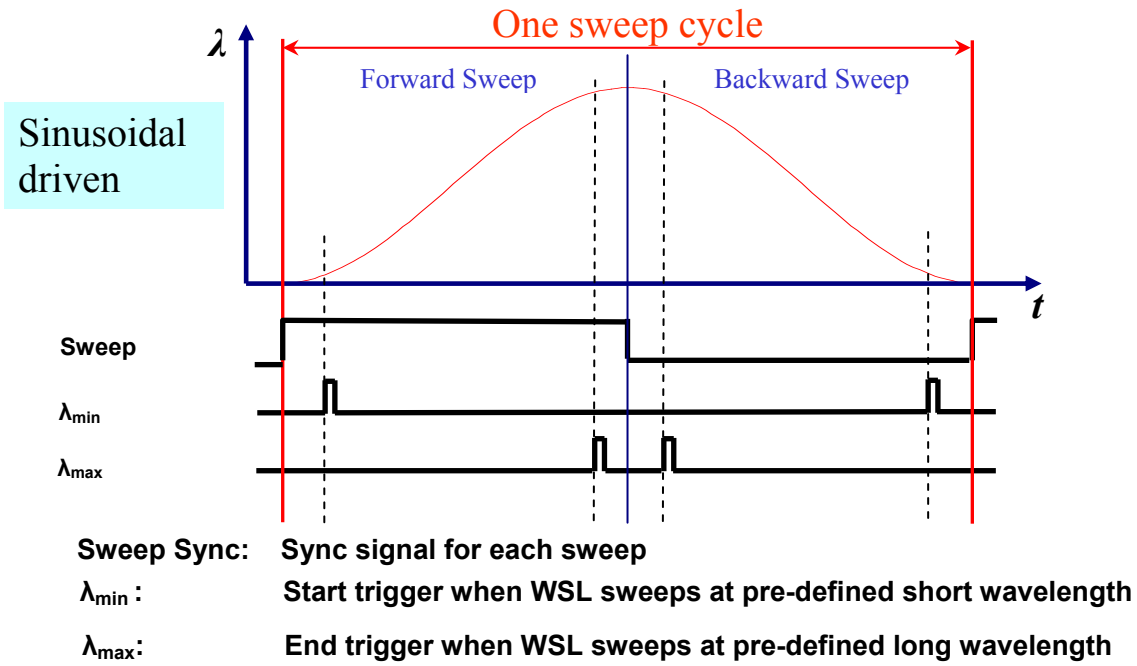


Fig. 2 Sweeping wavelength, Sweep sync, λ_{min} trigger, λ_{max} trigger timing relationship

The operation scheme of WSL-1000 in one sweep cycle is sweeping from short wavelength to long wavelength (Forward Sweep), and then sweeping back from long wavelength to short wavelength (Backward Sweep). WSL-1000 is driven by sinusoidal signal.

There are 3 TTL signals in WSL-1000 which could be used as timing reference:

1) Sweep Sync (Start at each sweep)
2) λ_{min} (Trigger when laser sweeps to certain pre-defined short wavelength)
3) $\lambda_{max,}$ (Trigger when laser sweeps to certain pre-defined long wavelength)

User can select λ_{min} and λ_{max} when ordering otherwise it will be selected by default. For 1310 nm we choose λ_{min} as 1255 nm and λ_{max} as 1365 nm as default. The timing relationship of sweeping wavelength, sweep sync, λ_{min} trigger, λ_{max} trigger is shown in Fig. 2.

3.2 Frequency Clock

WSL-1000 is a rapidly swept laser source for OCT imaging application and is driven by sinusoidal signal. In order to achieve the data sampling point equidistant in optical

frequency, a reliable and accurate recalibration signal (Frequency-clock or F-clock) is required.

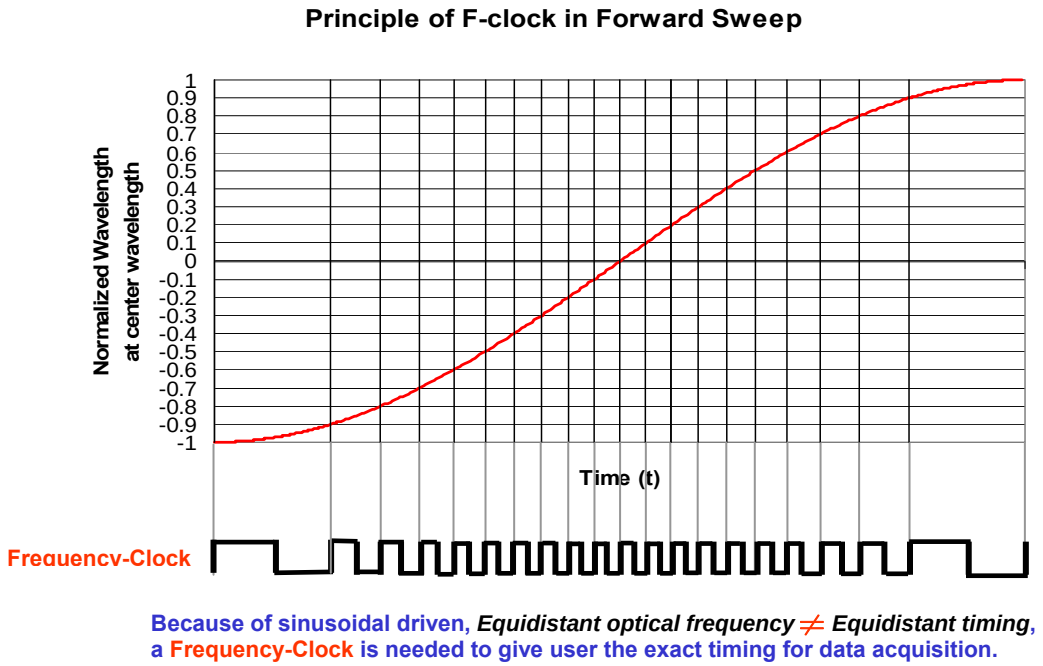


Fig. 3 Principle of F-clock

F-clock could be realized by Mach-Zehnder Interferometer (MZI). WSL-1000 is equipped with one free-space MZI and necessary electrical. It can give user a TTL trigger as the zero-crossing of MZI output which detects the change of input optical frequency. The spacing of optical frequency could be selected when ordering. By using F-clock, user can take the data exactly by equidistant optical frequency even the timing may not be equidistant; this approach also relaxes the worry about laser stability and repeatability.

MZI output

F-clock

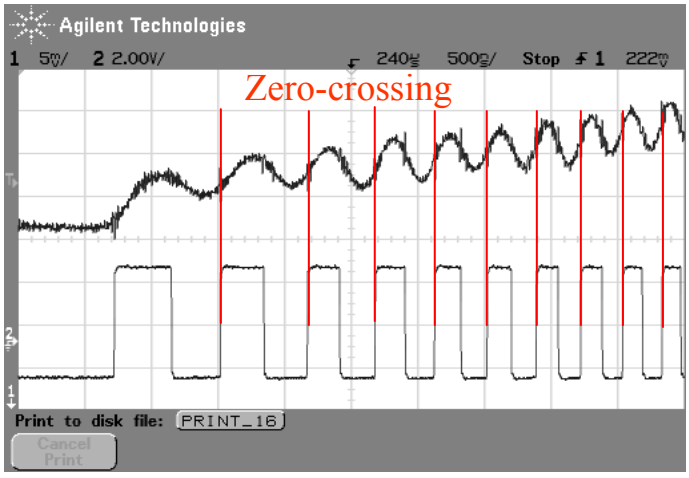


Fig. 4 A close view of F-clock

Below are the simple formulas to estimate the spacing of MZI for the F-clock and its data rate.

$$SP = \frac{c * \Delta\lambda}{\lambda^2 * N} \qquad (1)$$

SP	MZI frequency spacing
c	Light speed
$\Delta\lambda$	WSL spectral range (10 dB cutoff point)
λ_0	Center wavelength
N	Sample number in forward sweep

Since GP's WSL sweeps in both directions (forward & backward), a multiplication of 2 is necessary.

$$F = N * R * 2 \qquad (2)$$

F	F-clock data rate
R	WSL repetition rate

F could be used as a reference to choose your DAQ (Data Acquisition) card sampling rate.

3.3 Instantaneous Power Monitor

The instantaneous power monitor (0-5V, analog) is an analog signal which delivers an output voltage proportional to WSL-1000 optical output power intensity.

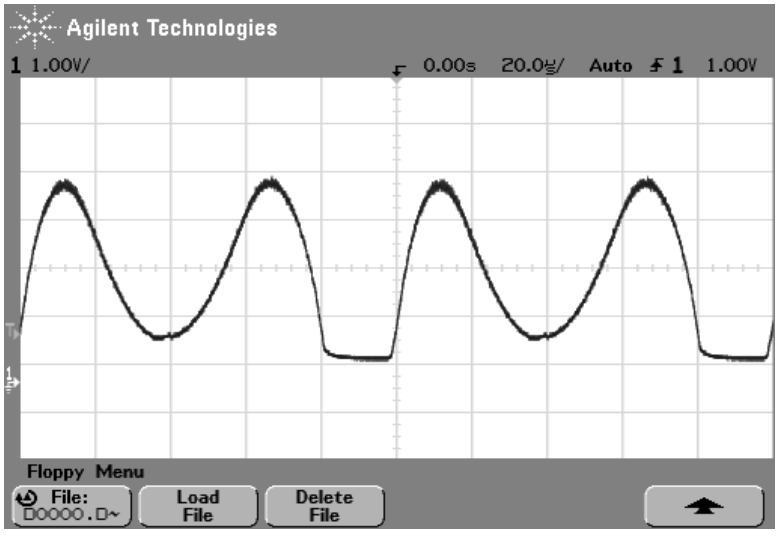


Fig. 5 Instantaneous power monitor signal

3.4 Interface Descriptions

3.4.1 Front panel

Fig. 6 Front panel layout

LCD display:	Displays operation status and parameter
POWER:	Power on/off switch
LIGHT:	Light source enable/disable key
SWEEP:	WSL sweep switch
GREEN LED:	Power and Light source LED
WSL OUTPUT:	WSL optical output (FC/APC)
Keypad:	Push buttons for operation status control.
Center key:	"ENTER" key to confirm or select displayed setting
Arrow keys:	Set parameter or move between setting options

3.4.1 Rear panel

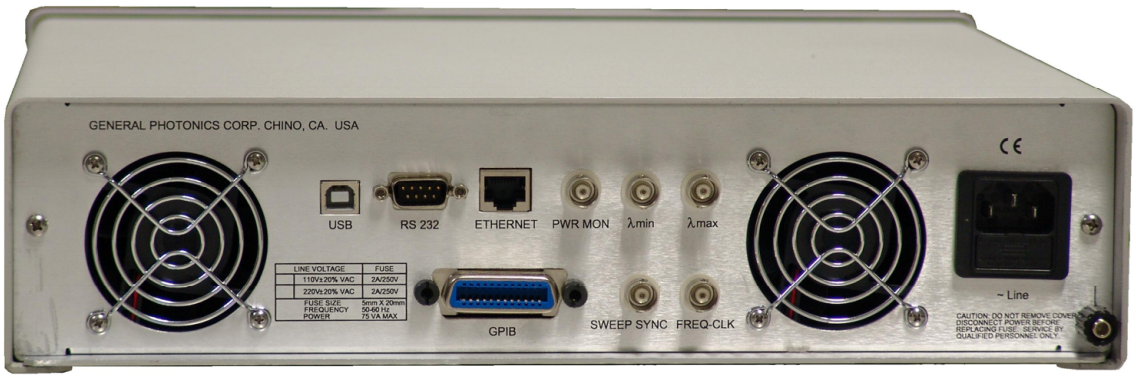


Fig. 7 Rear Panel

PWR MON	WSL instantaneous power monitor
λmin	Start trigger (at short wavelength)

λmax	End trigger (at long wavelength)
SWEEP SYNC	Sweep Sync (Start at each sweep)
FREQ-CLK	Frequency clock
USB:	USB interface port
RS-232:	Serial communication port
Ethernet:	Ethernet interface port
GPIB:	GPIB interface port
Line:	External AC supply input connector, 110 V or 220 V
	Electrical ground connection

Notes:

- In order to keep the proper signal integrity, please try to connect those signals as close as possible to your application.
- 50 ohms termination for Frequency Clock will help the signal integrity. However, the swing will be around 2-3 V.

Section 4 Programming and Control

WSL-1000 is equipped with RS-232, Ethernet, USB and GPIB. Since the command is common for all interfaces, we will only explain the programming through RS-232 port as example.

4.1 Programming

4.1.1 RS-232 connection

An RS-232 port is equipped to allow user to remotely control WSL-1000. Any program that supports RS-232 communication protocols can be used to send ASCII commands to the WSL-1000 to remotely control and access the system.

4.1.2 Programming Commands

The following commands are recommended to users who wish to write their own control programs for remote operation of the WSL-1000 using the RS-232 communication port.

1. Connect WSL-1000 and PC using RS-232 straight cable.
2. Referring to Table 1, send a command string to the WSL-1000. There are many programming languages that support serial communications, including Visual Basic, LabView and C.

Table 3 System Command List

System Commands	Description	Response	Remark
***IND n#**	**0: Turn off the command indication**	***E00# No error**	

	when return(default) **1: Turn on the command indication when return**	***E01# Undefined Command**	
***IDN?**	**Query WSL001 identification**	***** **GP-WSL001 V2.0#** **(default)**	
***VER?**	**Query WSL001 firmware version**	***** **V1.0.090518A#** **(default)**	
***RST#**	**Reset system parameter**	***E00# No error** ***E01# Undefined Command**	

Table 4 Control Command List

Control Commands	Description	Response	Remark
***SOA:ENA n#**	**0: disable SOA(default)** **1: enable SOA**	***E00# No error** ***E01# Undefined Command**	
***SCN:ENA n#**	**0: disable sweeping (default)** **1: enable sweeping**	***E00# No error** ***E01# Undefined Command**	
***ATT ff.f#**	**Set the output power attenuation.** **Unit: dB** **Range: 0~20dB (Default: 0)**	***E00# No error** ***E01# Undefined Command** ***E02# beyond the range**	
***POW:UNT n#**	**Set the unit of output power.** **0: dBm(default)** **1: mw**	***E00# No error** ***E01# Undefined Command**	
***FKM n#**	**Sets the multiplies of f-clock** **N=1,2 (default: 1)**	***E00# No error** ***E01# Undefined Command** ***E02# *E02# beyond the range**	**Only support "x1" right now**
***CSO n#**	**Customer set option for 'Alarm'** **'0': No action (default)** **'1': Shut down the laser in 100 ms**	***E00# No error** ***E01# Undefined Command**	**For laser safety purpose**

Table 5 Request Command List

Request Commands	Description	Response	Remark
***POW?**	**Query the output power**	***sff.ffffff# (default)**	**Default: dBm**

***SOA:STA?**	**Query the SOA status**	***n# (default)**	**0: disabled 1: enabled**
***SOA:CUR?**	**Query the current of SOA**	***ff.ff# (default)**	**Unit: mA**
***SOA:TMP?**	**Query the temperature of SOA**	***ff.ff#(default)**	
***SCN:STA?**	**Query sweep status**	***n#(default)**	**0: disabled 1: enabled**
***SCN:RAT?**	**Query the sweep rate of WSL-1000**	***ff.ff#(default)**	**Unit：kHz**
***POW:UNT?**	**Query the unit of output power**	***n#(default)**	**0: dBm 1: mW**
***FKM?**	**Query the multiplies of f-clock**	***n#(default)**	**n=1,2 (Only support 1 right now)**
***ATT?**	**Query the attenuation value**	***ff.ff#(default)**	**Unit: dB**
***WAV?**	**Query laser center wavelength**	***nnnn.n#(default)**	**Unit: nm**

Table 6 Command Response Codes

E00	No error (Correct command received)
E01	Undefined command
E02	Out of range

RS-232 port setting: Asynchronous framing, 8 data bits, no parity bit, and 1 stop bit, 9600 bps.

If a problem occurs during RS-232 control, please check the following items:

1. Cable should be straight-wired: Select a straight-wired (pin-to-to pin wired) cable;
2. Verify active Comm Port (COM1, COM2, etc.). This can be done by looking under "Device Manager" on the "System Properties" screen: select Control Panel → System Properties → Hardware → Device Manager, and then Select View → Devices by type, and look under Ports;
3. Verify Comm Port setting: 8 data bits, 1 stop bit, no parity bit, 9600 bps
4. Check command format: it should begin with "*" and end with "#" or "?"
5. Sometimes communications may freeze (overflow) due to port conflict (this mainly happens during ETHERNET control). In this case, the user may need to restart the instrument to re-enable remote control.

4.2 Remote Control Toolkit

Except the front-panel operation, WSL-1000 could be controlled by a PC through RS-232 interface. A "Remote Control Toolkit" (RCT) which is a GUI (Graphical User Interface), was developed for this purpose. As long as POWER and LIGHT enable key is at "On" position, user can easily control WSL-1000 from PC to get the necessary information.

Fig. 11 Control WSL-1000 from PC by "Remote Control Toolkit"

4.2.1 Introduction

RCT is developed by Labview (National Instruments). It is consists of RS-232 port selection, and 3 application pages.

RS-232 port selection: RCT has to work after the RS-232 communication established. First of all, please select the correct RS-232 port to PC. The default is "COM1".

RS-232 port setting**:** Asynchronous framing, 8 data bits, no parity bit, and 1 stop bit, 9600 bps

Please be advised that RCT only support most useful commends of WSL-1000 (not full commend set).

We also confirmed that USB2RS232 adaptor works with RCT so it is easy to use PC with USB and USB2RS232 adaptor to control WSL-1000. The condition is:

1) Install NI development environment (included in WSL installation CD)
2) Install adaptor driver

Reference USB2RS232 adaptor link:

http://www.kinamax.com/product/Item/CB-RS232.htm

Note: When WSL-1000 is controlled by RCT, an “L” (Local) is displayed at WSL-1000 LCD. Under such situation, if user pushes any button, the control will be returned to “Local”.

Application pages:

- Basic information
- Configuration
- Status report

4.2.2 Basic Information

In this page user can get the basic information of WSL-1000 module.

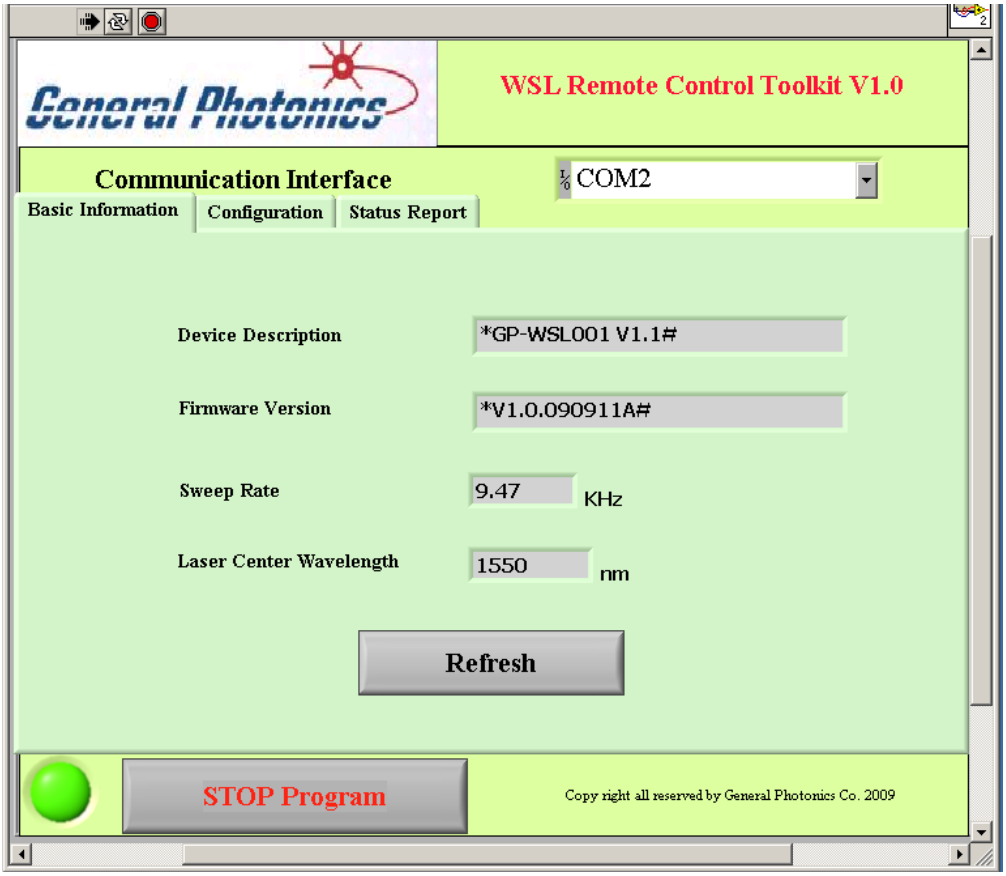


Fig. 12 Basic information

- **Device Description**: WSL-1000 identity
  (Same function as: *IDN?)

- **Firmware Version**: WSL-1000 firmware version
  (Same function as: *VER?)
- **Sweep Rate**: WSL-1000 scanning rate
  (Same function as: *SCN:RAT?)
- **Laser Center Wavelength**: WSL-1000 center wavelength
  (Same function as: *WAV?)

Please use "Refresh" button to get the latest information.

4.2.3 Configuration

In this page user can configure WSL-1000 to meet user's requirement. It includes "Sweep Switch", "Laser Switch" and Attenuation setting. User can also choose the unit of optical power as either "dBm" or "mW". At the moment, "F-Clock Multiplier Set" only supports "x1" so it is not adjustable. By clicking "Reset" button user can get the default settings.

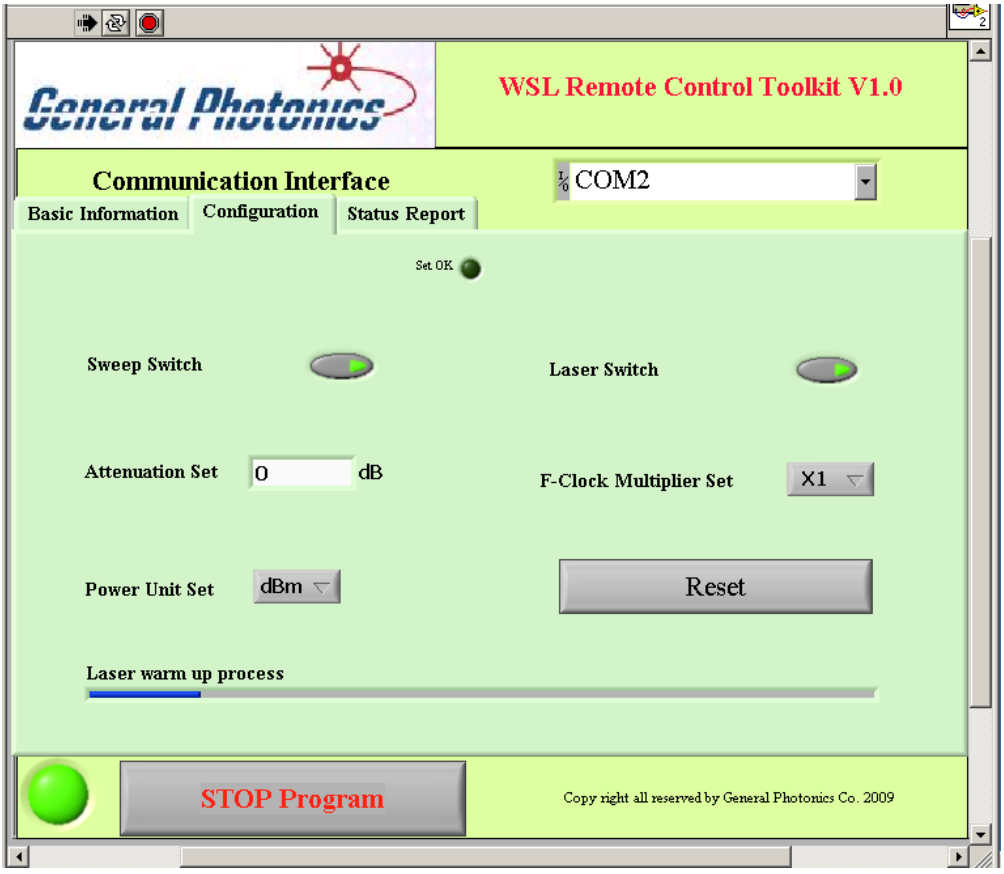


Fig. 13 Configuration

- **"Set OK"** LED: After setting one parameter, the LED "on" (LED becomes green) will indicate if the setting is successful.

- **Sweep Switch**: Click the button to turn on (LED on) or off (LED off) laser sweeping.

- **Laser Switch**: Click the button to turn on (LED on) or off (LED off) laser.

  Notice:
  1. Per FDA and IEC 60825 regulation, there are 3 seconds delay to turn on the laser.
  2. System needs about one minute to warm up the laser. A progressive bar will show the status of the laser warm up.
  3. During laser warm up, there is optical output but the laser intensity is not stable. Please wait until "Set OK" LED becomes green.
- **Attenuation Set**: Set the attenuation value for WSL-1000 optical output. The precision is 0.1 dB and the attenuation range is 20 dB.
  (Same function as: *ATT ff.f#)
- **F-Clock multiplier Set**: Set the F-Clock multipliers. Currently only 1x is available.
  (Same function as: *SCN:RAT n#)
- **Power Unit Set**: Set the optical power unit for either "dBm" or "mW".
  (Same function as: *POW:UNT n#)
- **Reset**: System reset to default.

Default:
- Laser Switch: off
- Sweep Switch: off
- Power unit: dBm.
- F-Clock multiplier: x1
- Attenuation: 0 dB

4.2.4 Status Report

In this page user can get the status report of WSL-1000. It includes "Sweep Enable", "Laser Enable", "Attenuation", "F-Clock Multiplier", "Power Unit", "Power" and the laser health information such as "Laser Current" and "Laser Temperature".

There is one "Warning/Alarm Message" window to show the warning or alarm message.

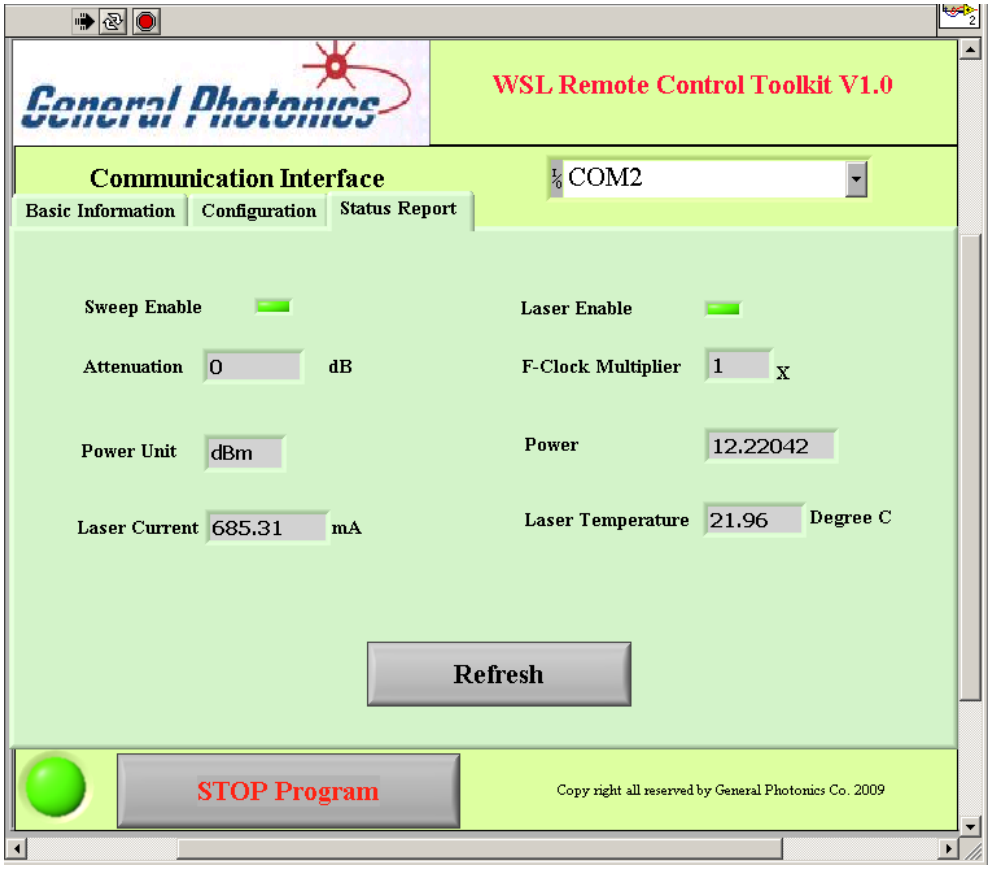


Fig. 14 Status Report

- **Laser Enable**: LED indicates the laser status.
  (Same function as: *SOA:STA?)
- **Scanning Enable**: LED indicates the scanning status.
  (Same function as: *SCN:STA?)
- **Attenuation**: Show the attenuation value.
  (Same function as: *ATT ff.f# and *ATT?)
- **F-Clock multiplier**: Show the F-Clock multiplier
  (Same function as: *FKM n# and *FKM?)
- **Power Unit**: Show the optical output power unit
  (Same function as: *POW?)
- **Power**: Show the value of optical output power
  (Same function as: *POW?)
- **Laser Current**: Show the value of laser current
  (Same function as: *SOA:CUR?)
- **Laser Temperature**: Show the value of laser temperature
  (Same function as: *SOA:TMP?)
- **Refresh**: Get the refresh information from WSL-1000

Section 5 Operation Instructions

Getting started

Unpacking

Packing list:

WSL-1000 instrument	1
WSL-1000 manual	1
AC Power cable	1
CD	1
(Remote Control Toolkit and this manual)	

Inspect WSL-1000 for any physical damage due to shipping and transportation. Contact carrier if any damage is found. Check the packing list to see if any parts or accessories are missing.

Initial setup

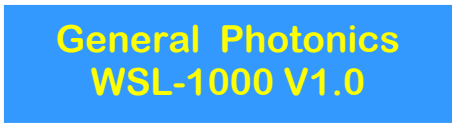
- Connect necessary BNC signals (Sweep Sync, F-clock, triggers, etc.) if necessary
- Connect AC power cable.
- Connect the optical output to your application. Since WSL-1000 at static mode could have up to 50 mW optical power, using an attenuator between WSL-1000 and your measurement or application is recommended.

Operation

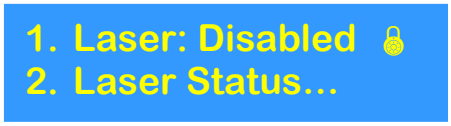
Basic operation

- Initialization

When WSL-1000 is first powered on, it will go through an initialization process. During this time, the LCD will display the following initialization screen:



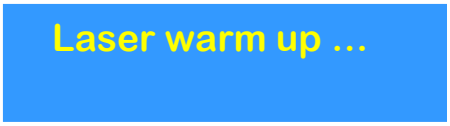
When initialization is complete, the LCD displays:



The symbol " 🔒 " means that the laser key is locked. In order to turn on the laser, user has to turn on the laser key.

- Laser on and warm up

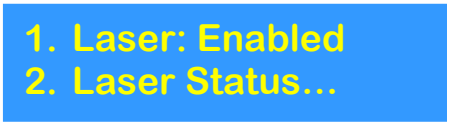
Turn on the laser key, and push "ENTER" key to enable laser.



Please be advised that laser will have 3 seconds delay per Class 3B laser safety requirement (ANSI Z136, IEC 60825), and about one minute for warm up. During laser warm up, there is optical output but the laser intensity is not stable.

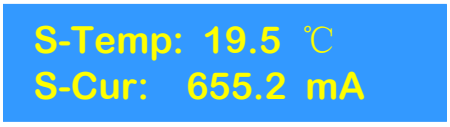
- Laser information

When laser warm completed, LCD displays:



Move arrow key to "2.Laser Status…" and push "Enter" key, user will have laser information as follows:

(Power: WSL optical output power;
Swp: Sweep rate)



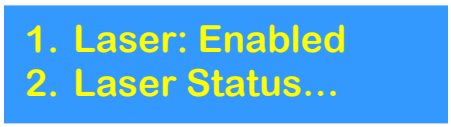
(S-Temp: Semiconductor Optical Amplifier (SOA) temperature;
S-Current: SOA current)

(Center-λ: WSL center wavelength)

Above 3 screens could be switched by pushing either "down" or "up" arrow key. If user wants to get out of "Laser Status" menu, please push "Left" arrow key.

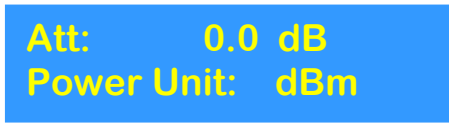
- Instrument setup

  From the screen

  Push “down” arrow key to get into “Setup” menu

  Push “ENTER” key, user will be able to set up necessary parameter as follows:

  (Att: Optical power output attenuation. The range is 0-20 dB;
  Power Unit: Choose optical power unit for “dBm” or “mW”)

  (Freq Clk: Set the multiplies of Frequency. Only “x1” is supported.
  GPIB Addr: GPIB address)

a) Static mode

At “Static mode” WSL will only give a laser output at center wavelength without sweeping. User can have highest laser output power under this mode.

1. Turn on the power
2. Enable the laser
3. Go to “Setup” menu to adjust the parameter if needed.
4. Turn off the laser key if user wants to shut-down the laser.
5. Turn off the power supplies

b) Sweeping Mode

1. Turn on the power
2. **Push “Sweep” button to turn on sweeping**
3. **Enable the laser**
4. Go to “Setup” menu to adjust the parameter if needed.

5. **In order to shut-down WSL output, please turn off the laser key first, and then turn off "Sweep". Disorder this procedure may cause WSL-1000 go to "Static mode", the output power could be up to 50mW!**
6. Turn off the power supplies

Notes:

- Due to environment reason, WSL may not be stable right after power on. Please turn on both "SWEEP" and "LIGHT", and wait about 10 minutes for a sufficient warm up.

Section 6 Technical Support

The WSL-1000 can be serviced only by manufacturer authorized personnel. There are no user serviceable components in this system.

General Photonics is committed to high quality standards and customer satisfaction. For any questions regarding the quality and the use of the WSL-1000, or future suggestions, please contact General Photonics Corporation at (909)-590-5473 (telephone) or (909)-902-5536 (fax), or by e-mail at info@generalphotonics.com or info@octpro.com. General Photonics will respond to all customer questions within 24 hours during regular business hours. You can also write to:

General Photonics
5228 Edison Avenue
Chino, California 91710
USA

Disclaimer:

1. General Photonics receives the right to make changes in module/instrument design or specifications without notice.
2. The information supplied by General Photonics in this documentation is believed to be accurate and reliable. However, General Photonics assumes no responsibility for its use, nor for any infringements of third parties, which may result from its use.